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JPICAM TM-8

FINAL PROGRESS REPORT for the LIGHT-WEIGHT TELEVISION CAMERA

Prepared for:

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA 3, CALIFORNIA

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ASTRO-ELECTRONIC PRODUCTS DIVISION
PRINCETON, NEW JERSEY

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BY:
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PRINCETON, NEW JERSEY

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ABSTRACT

The object of this program was to build a light-weight camera for taking pictures of the back side of the moon. AEP built a laboratory bench model, six flight models, and three monitors, all meeting JPL specifications. The camera was designed as part of a system including a tape recorder and a small transmitter. This report contains a functional description of the system, a physical and operational description of the equipment, a summary of operating procedures and environmental tests performed, and a list of specifications.



INTRODUCTION

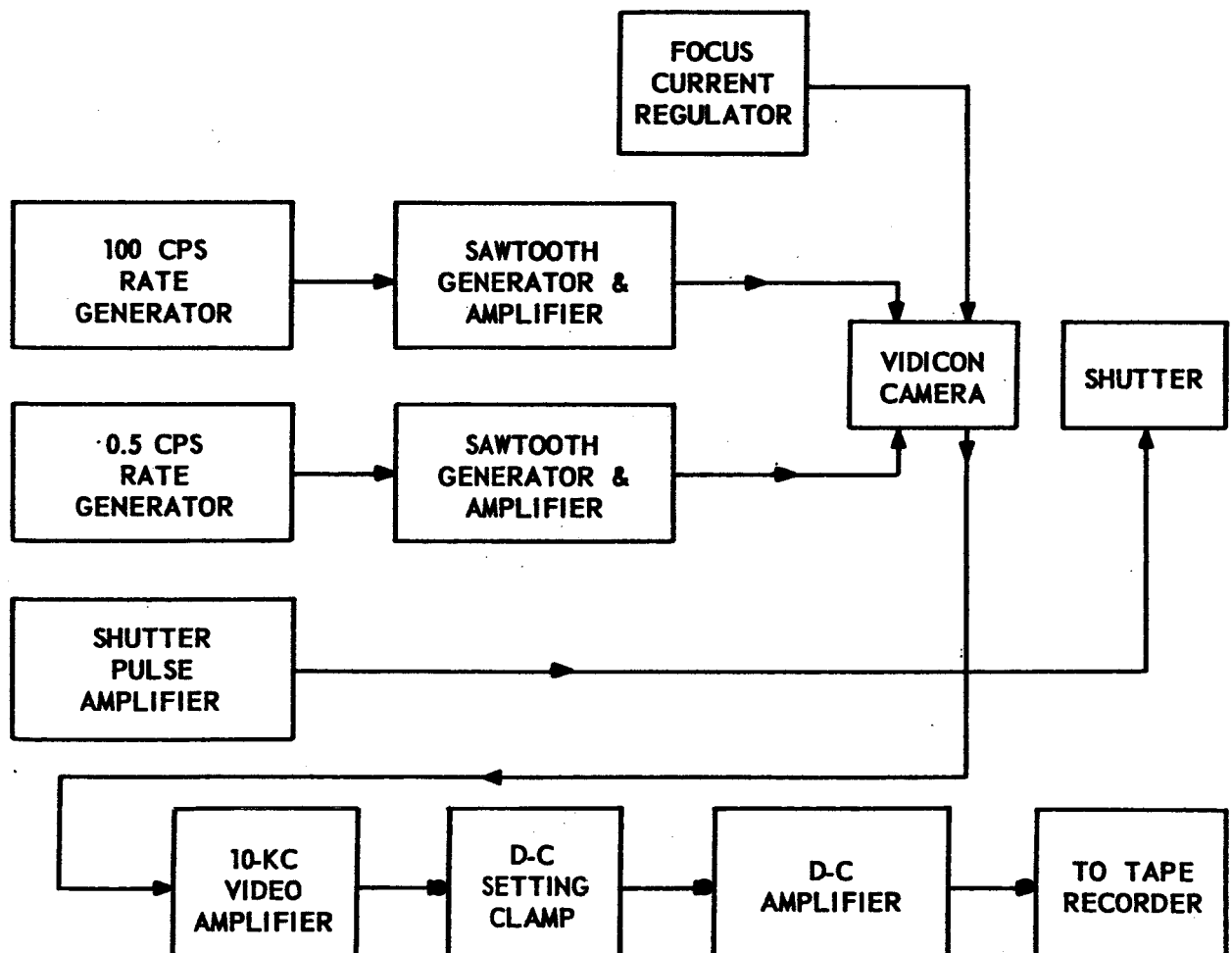
The purpose of this project was to build a camera of very light weight for taking individual pictures of the back side of the moon. The requirements called for a camera under five pounds and with a power consumption less than ten watts. This was originally required to take four pictures at a distance of 20 to 40 thousand miles. This requirement was later altered to give a full picture of the moon at 15 thousand miles.

This camera, made by AEP, was designed to be a part of a system including a tape recorder with extended playback time and a small transmitter.

In addition to building a laboratory bench model and six flight models, AEP also built three monitors late in the program.

SYSTEM DESCRIPTION

SYSTEM BLOCK DIAGRAM



The camera includes a horizontal and vertical synchronizing generator furnishing 100 cps pulses and 0.5 cps pulses. These pulse generators feed the horizontal and vertical saw-tooth generators and amplifiers which drive the magnetic deflection yoke. Magnetic focusing is used and a part of the camera is devoted to accurately controlling the necessary current. Another part of the camera is the shutter pulse amplifier which furnishes a high-current pulse to the solenoid which actuates the shutter. The video amplifiers have bandwidth limited to 10 kc, although this camera may very readily be altered to operate with 400 to 500 lines with an appropriate extension of the video bandwidth. The actual wiring diagram for connection between boards is shown in Figure 1.

EQUIPMENT DESCRIPTION

Physically, the camera is mounted on two printed circuit boards 1.5 inches apart with the components facing. These boards are 7.5 inches in diameter and fit into the vehicle case.

The vidicon yoke and lens are mounted on a ribbed aluminum platform which also supports the two printed circuit boards, the optical trigger and the despin timer. The lens-vidicon axis is 20 degrees from the plane of the board and intersects the spin axis. Between the lens and the vidicon is a Lieca shutter with an effective exposure of one millisecond. The boards are conformally coated with an epoxy resin and are backed by a layer of foam which is in contact with an aluminum plate. This foam and metal sandwich stiffens the boards and acts as a heat sink, a thermal conductor, an electrical insulator and a vibration damper. The conformal coating of epoxy resin is a heat conducting medium and a bonding cement to secure the components solidly to the boards. This coating and foaming was deferred at JPL's request that they be allowed to add them later. As a result of this request the first two units were returned to be replaced by two uncoated units.

Signals originating due to the scanning process of the vidicon are amplified by a vacuum tube pre-amplifier. The signal current is of the order of magnitude of 2 to 8 millimicroamperes with one thousand foot-lamberts, using a millisecond exposure with an f 1.6 lens. The pre-amplifier is of the cathode-follower type employing a Sylvania 5904 tube. Since a current source is needed to drive the first transistor, this cathode follower is actually acting as a current amplifier. The signal-to-noise ratio is about 16 db better than that obtained with a transistor.

The video amplifier following the pre-amplifier consists of stages using NPN-PNP d-c coupled pairs (See Figure 2). Each pair is capacitor-coupled to the next stage and employs two feed-back loops. One loop is inherent in the connection and uses a high loop gain, while the other runs from output to input through a feed-back resistor and has a much lower feed-back factor which is just enough to provide d-c stability as a function of temperature.

A high frequency by-pass in one feed-back circuit is used for high peaking. Zener diodes are used on each individual pair to insure decoupling and immunity to voltage variations.

A keyed clamp is used for d-c restoration with d-c coupling out to the tape recorder deck. The d-c amplifier consists of a boot-strap pair which creates a high load impedance for the clamp which it follows.

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The output stage is an emitter follower. The dark-current pedestal is clipped in this d-c amplifier, reducing the required dynamic range for the tape recorder. A sync voltage is introduced in the boot-strap pair so that uniform clipping occurs during blanking, and this signal is then added again in the emitter of the output stage where it pushes the sync voltage tip to within a fraction of a volt of ground. It is adjusted to be about 0.5 volts with white video at about three volts. The video amplifier is designed to work into a 3.9-thousand ohm load.

The deflection amplifiers are driven from horizontal and vertical rate generators which are stabilized transistor multivibrators operating at 0.5 cps and 100 cps (See Figure 3). Pulse widths are 200 ms and 1 ms, and the vertical and horizontal circuits are interlaced to improve its stability.

The vertical deflection amplifier is d-c coupled. On the earlier models the horizontal amplifier was a-c coupled into the yoke employing a 4-henry choke. The choke was eliminated on later models by replacing it with a d-c coupled circuit using a zener diode as part of the centering bridge. Because the earlier models were conformally coated, they were not included in the six delivered on contract. The use of d-c coupling not only eliminated weight, but also gave better linearity, and in turn, minimized scan-oriented shading and made the shading compensation which was provided essentially unnecessary.

The shutter actuation circuit consists of a transistor switching circuit which drives a relay type solenoid. The relay arm strikes the shutter release button with enough force to trigger the shutter mechanism. In order to prevent a high peak current load on the battery, the power for the solenoid is furnished from a charged condenser which is isolated from the battery. Refer to Figure 4.

The d-c converter is in a separate box for mounting on the battery ring. It consists of a square loop transformer driven by the transistor inverter.

TESTING AND CALIBRATION

The list of environmental tests as specified by JPL were carefully executed on number 1 and number 4. This included a resonance search at 5 g's for 18 min. in three planes. Resonance was noted at 1100 cps, 5 g input -12 g output. A random noise test for 1 minute in three planes cycled at 15 g for 8 sec. and 25 g for 0.2 sec.

Seventy-five g static acceleration and 100 g shock were applied to the unit. The shock was repeated in four increasing steps. A spin test at 900 rpm was also performed.

The camera was operated electrically following each test. No failures occurred.

The cameras were adjusted and tested in a hot-cold temperature environment chamber and made to operate between +10 degrees C and +50 degrees C.

A test in the vacuum chamber to 350,000 feet altitude was made without incident.

The camera was required to give specified video output with 1,000 foot-lamberts illumination.

OPERATING PROCEDURES

The camera is not provided with any operating adjustments, being pre-adjusted for each vidicon. It was initially set up with potentiometers in key positions which were replaced by fixed resistors.

For initial operation an illumination of 3 to 4 foot-lamberts should be used with the shutter locked in the open position. After focusing the shutter may be operated in the usual manner with 1,000 foot-lamberts illumination. It was initially intended to ship cameras with lenses set at infinity, but, in order to allow JPL to try cameras on standard test patterns, this adjustment was deferred for the field engineering phase of our contract.

The following procedure is used. A projector designed to project an image of a transparency with collimated light (projecting parallel rays) should be used and the lens adjusted for optimum focus. The lens is then locked into position. The defocussing due to vacuum is very slight with the lens employed, but it is recommended that this adjustment be checked in a vacuum chamber with the collimator projecting through the window of the chamber.

SPECIFICATIONS

Horizontal Rate	100 cps
Horizontal Pulse Width	1 millisecond
Vertical Rate	0.5 cps
Vertical Pulse Width	200 millisecond
Video	
Sync	-0.5 V to 0 V
Video	-3 V to -0.5 V
Output Load	3900 ohms
Bandwidth	10 kc
Shutter Trigger	20 millisecond; 1 volt
Shutter Speed	1 millisecond
Optics	.2 inch lens, f 1.6
Power Consumption	8.2 watts
Voltage Required	
Camera Circuits	25 V
Vidicon Filament	6.3 V at 100 ma
Weight	4.3 lbs.
Vidicon Image Size	¼ inch by ¼ inch

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**DRAWING AND PARTS LIST LIGHT WEIGHT TV CAMERA
LIECA SHUTTER**

1170022	Pedestal - Release Mech. Ass'y.
1170024	Bracket - Rear
1170025	Support - Rear Bracket
1170028	Actuator
1170033	Mounting - Rear Bracket
1170036	Clamp
1170107	Lens Mount Detail
1172043	Bracket Ass'y Solenoid
1172048	Pedestal - Heat Sink Ass'y
1172049	Mounting Bracket
1172089	Terminal Block Ass'y
1172096	Amplifier Cover
1172097	Yoke - Mod
1176045	Light Weight TV Camera Ass'y
1176058	Yoke Housing
1177081	Platform
1177082	Frame
1177092	Cavity
1177119	Cover Ass'y
1176029	Schematic Synchronous and Deflection
1176030	Schematic Video Amplifier
1176031	Schematic High Voltage and Auxillary Circuits
1173026	Schematic Wiring Diagram

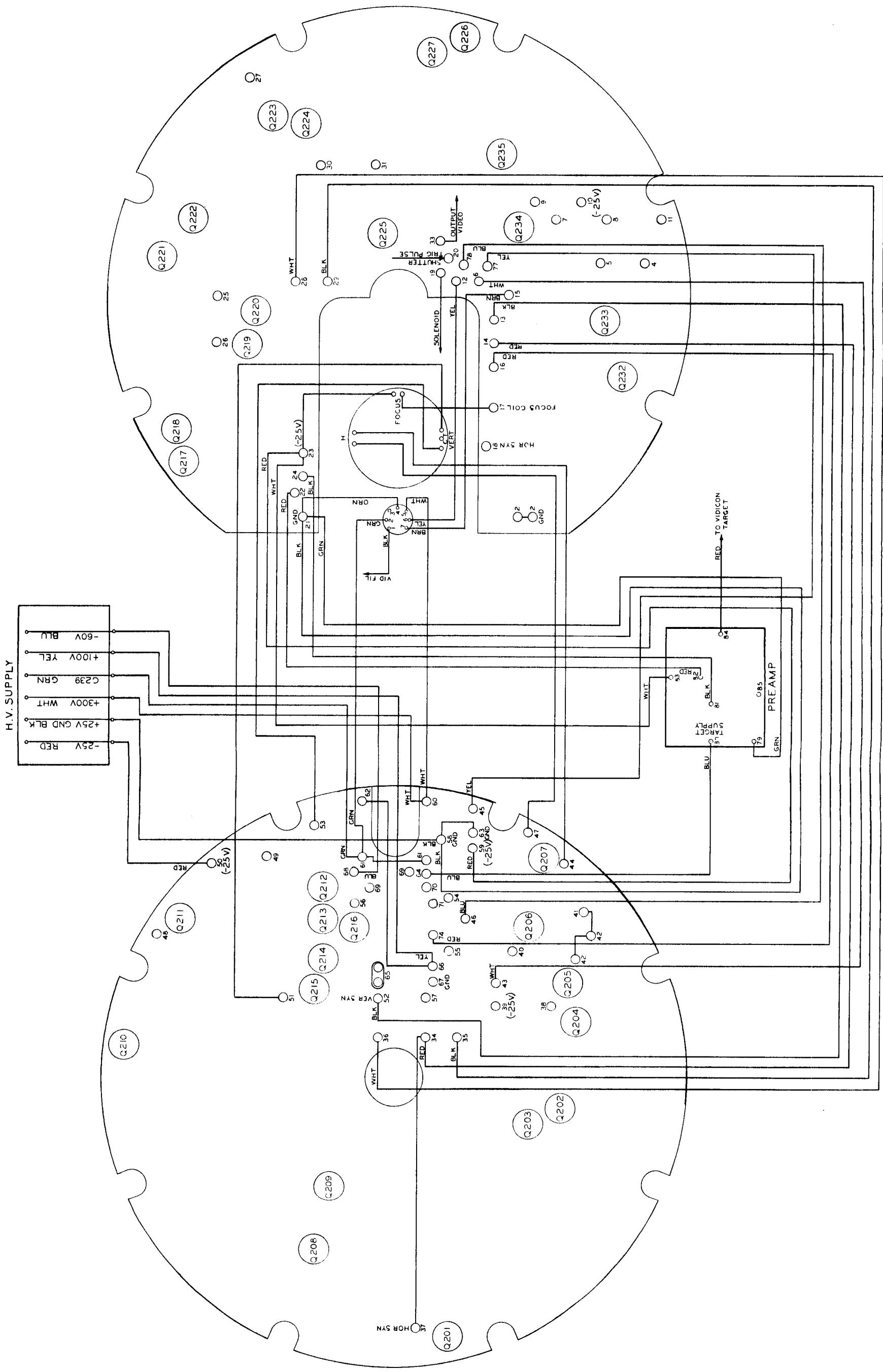
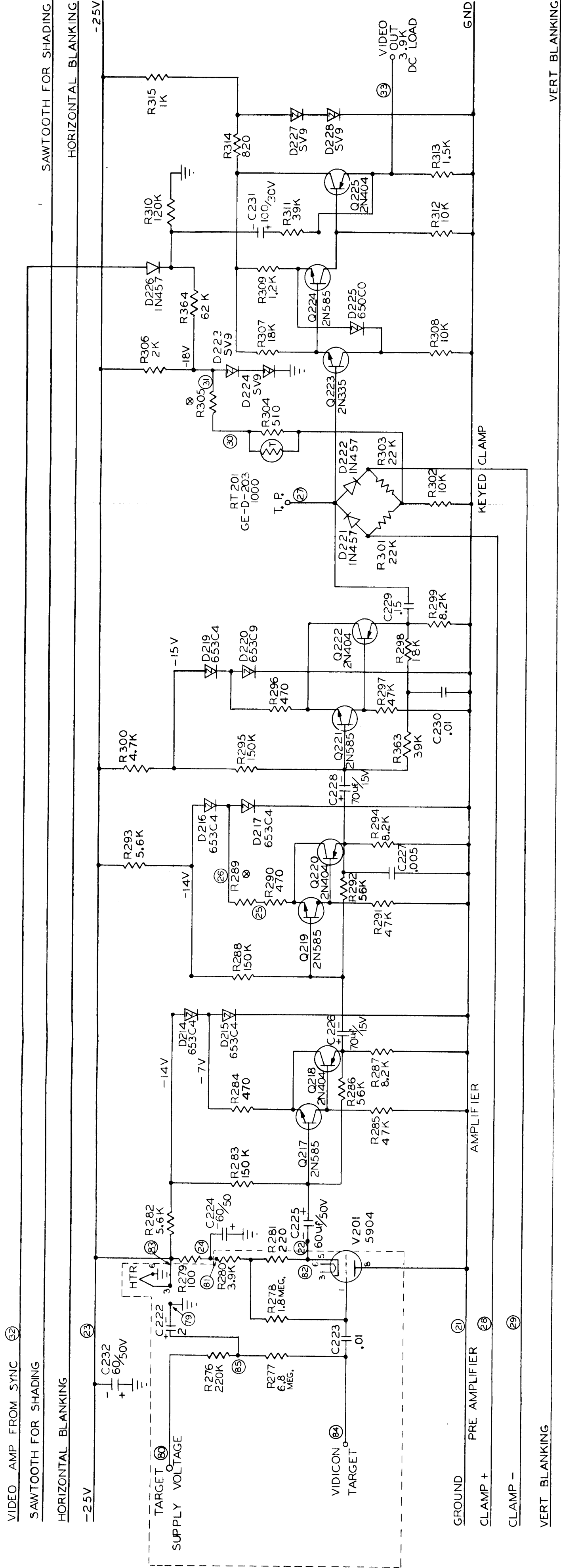


Figure 1. Wiring Diagram



NOTES:

- 1. RESISTANCE VALUES ARE IN OHMS
- 2. ALL RESISTORS $\frac{1}{4}$ WATT UNLESS NOTED
- 3. CAPACITANCE VALUES ARE IN UF & 100V UNLESS NOTED
- 4. FOR ELECTRICAL PARTS LIST REFER TO A-1170007
- 5. Ø VALUE TO BE DETERMINED BY TEST FOR SPECIFIC VIDICON.

Figure 2. Video Amplifier

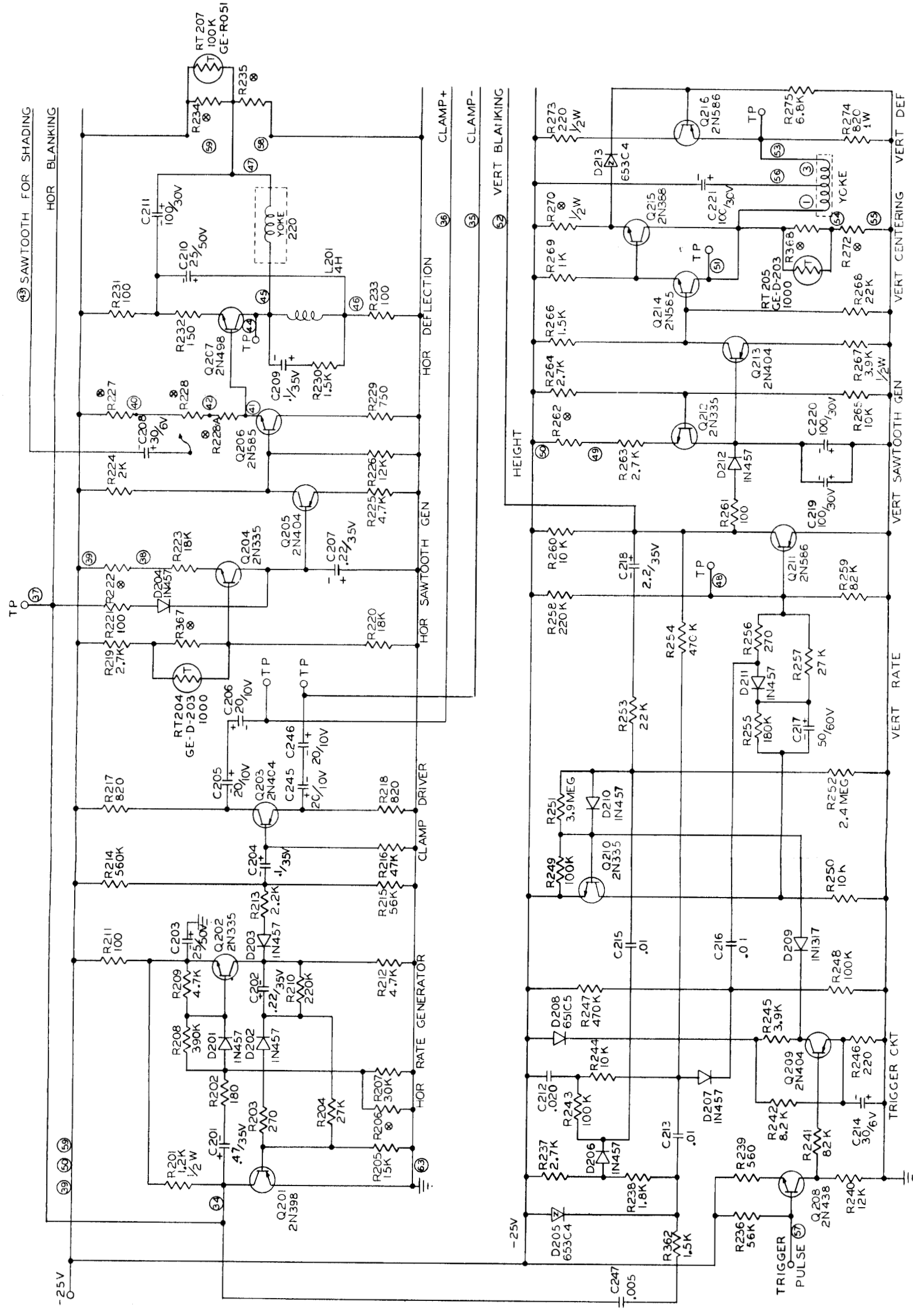
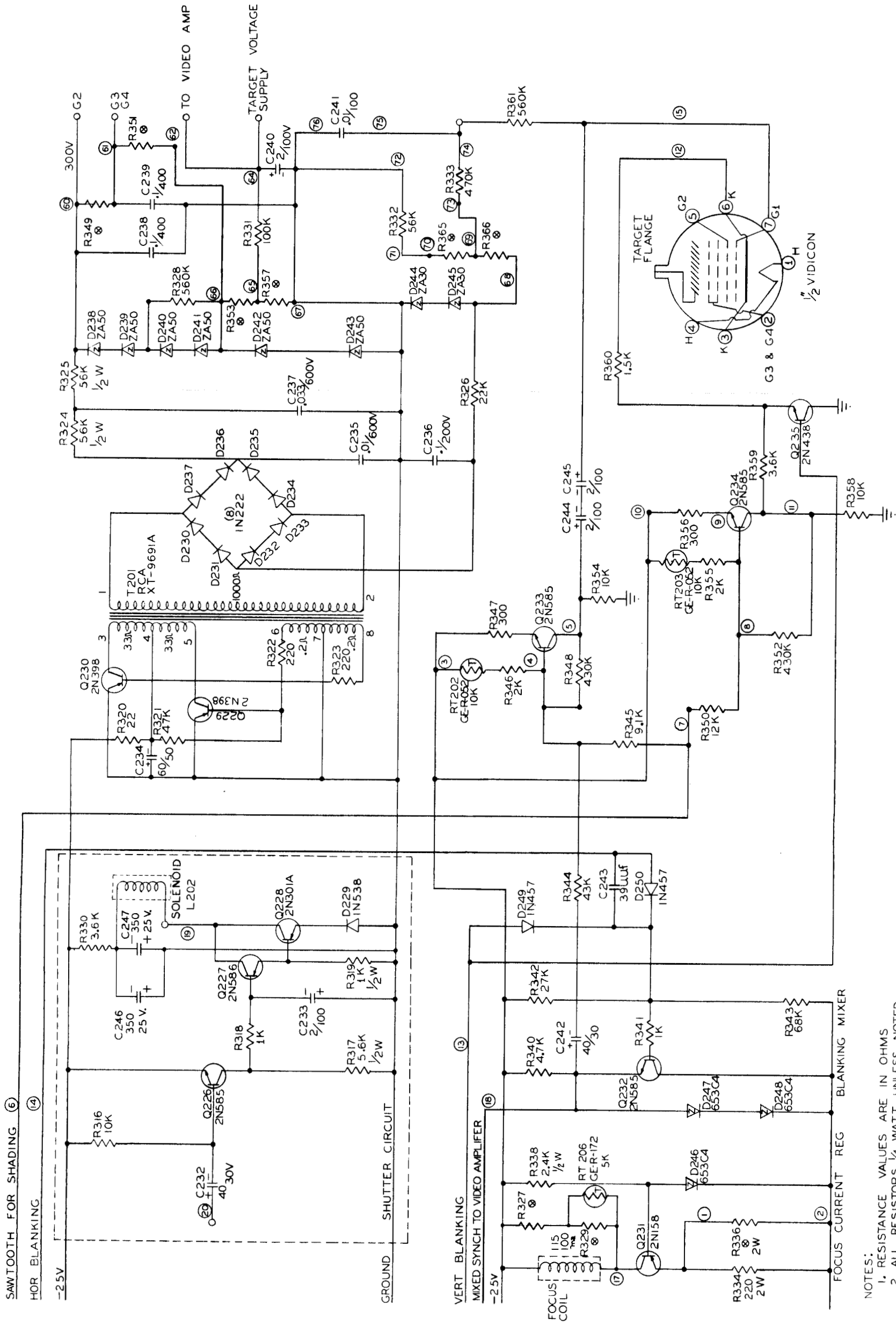


Figure 3. Synchronous and Deflection Circuits



NOTES:
1. RESISTANCE VALUES ARE IN OHMS
2. ALL RESISTORS 1/4 WATT UNLESS NOTED
3. CAPACITANCE VALUES ARE IN UF & 100V UNLESS NOTED
4. FOR ELECTRICAL PARTS LIST REFER TO A-1170008
5. VALUE TO BE DETERMINED BY TEST FOR SPECIFIC VIDICON

Figure 4. High Voltage and Auxiliary Circuits